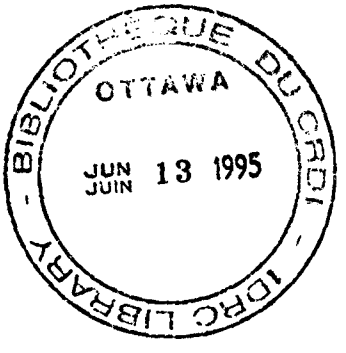
Report on a visit to the Centro de Investigaciones Ecológicas del Sureste, Tapachula, Chiapas, Mexico, November 1-12, 1993, to evaluate the Coffee Berry Borer Research Project.

A.S. McClay, Ph.D.

15 Greenbriar Crescent
Sherwood Park, Alberta
Canada, T8H 1H8

IDRC Fil[redacted]

December, 1993



CONTENTS

1 General

1.1 Human resources

The coffee berry borer team at CIES includes five researchers on the permanent staff (Ings. Juan Francisco Barrera, Jaime Gómez, William de la Rosa, Francisco Infante and M.C. Antonio Gutierrez), two additional staff on contract, Ing. Alfredo Castillo and Ms. Anne Damon, five permanent and four contract technicians. My discussions were mainly with Ing. Infante, who is acting project leader in the absence of Ing. Barrera, but I also met with Ings. Gómez and de la Rosa, Ms. Damon and Dr. Liedo, Coordinator of the Tapachula campus of CIES.

I was impressed by the high morale and enthusiasm of the team members I met and by the productive atmosphere of the Tapachula laboratory. They are keen to have CIES project an image as a reliable, productive organization generating information useful to producers, aware of and responsive to their needs, and continually providing new ideas and techniques. The interest in their work shown by the growers and the demand for training in biological control suggest that these efforts have been well received by the grower community. Government agencies involved in agriculture in Mexico have not invariably had such a high profile or reputation among their clients. I found the team members to be well informed of current developments in biocontrol. The library at Tapachula has an adequate range of subscriptions to journals in their areas of interest, which arrive promptly. Through the main CIES campus in San Cristóbal de las Casas, staff also have access to computerized literature searching.

Funding is available for postgraduate studies overseas; of the coffee berry borer biocontrol team, Ing. Barrera is currently completing a doctorate in France, Ing. Castillo is studying for a master's in Costa Rica, Ing. Infante is planning to enter a doctoral program at Imperial College, London (Silwood Park), and Ms. Damon is planning a doctoral program as an external student of Wye College, London. The station has also received frequent visits from biocontrol researchers and entomologists outside Mexico, such as Dr. Villacorta from

Brazil, who spent a sabbatical year at CIES, and Dr. Van Driesche of the University of Massachusetts, who visited in 1993 to give some lectures on the evaluation of the effectiveness of biological control agents. These contacts, together with activities such as the Intercontinental Coffee Berry Borer Meeting held at Tapachula in November 1991, have helped to keep staff up to date despite the relative isolation of Tapachula.

The station at Tapachula has few other research or academic institutions in its immediate vicinity. However the SARH Moscamed (Medfly) Program located nearby at Metapa is currently undergoing a major expansion to tackle several other fruitfly species. This is a major centre of expertise in mass rearing and field release both of (sterilized) insect pests and parasitoids, which may well be of assistance to the coffee berry borer program in the development of rearing and release techniques. The coordinator of the CIES unit, Dr. Liedo, who was previously employed in the Moscamed program, still maintains some research activities there and is well placed to facilitate links between the two programs.

Overall, I felt that the team has reached a critical mass which has sufficient strength and diversity of skills, as shown by their achievements to date, to make an effective contribution to solving the coffee berry borer problem in Mexico. The funding provided by IDRC has played an important role in creating this state of affairs.

From the limited observations made during my visit, morale appears to be high in the research community in general. Although living conditions for most people are still difficult, economic conditions in Mexico are improving, and the present government has adopted a more open policy on international trade. Government appears to be making a real commitment to supporting research and development in Mexico. (As in most countries, of course, such support is mainly focussed on "high-tech" areas such as computing and molecular biology, with less emphasis on the agricultural and environmental areas.) These changes have resulted in better salaries for researchers, more funding for research, more opportunities for overseas travel and training, and easier access to imported equipment and supplies. Although these developments may reduce the need for outside aid to some extent,

they also mean that Mexican projects are well placed to make effective use of aid funding for research.

2 Research progress, current activities and needs

2.1 Progress

The research progress of the project has already been detailed in the reports submitted to IDRC, and will only be briefly summarized here. The objectives of the project were:

- to mass rear the parasitoids of the coffee berry borer at Tapachula and conduct laboratory studies on their biology

- to establish the parasitoids in coffee plantations in Mexico

- to introduce additional species of parasitoids to Mexico

- to conduct bioecological studies on the parasitoids in the field.

Briefly, rearing methods have been developed for the bethylid parasitoids *Cephalonomia stephanoderis* and *Prorops nasuta*. A colony of *P. nasuta* from Africa died out before field releases could be made, but further material was obtained from the Brazilian population, and this has been successfully cultured and field released. An artificial diet has been developed for mass rearing of the coffee berry borer to allow parasitoid rearing to continue throughout the year. Laboratory studies have been conducted on the morphology of adult and immature stages of *C. stephanoderis*, its thermal requirements for development, intraspecific competition and superparasitism. *C. stephanoderis* is well established in the field and early results with *P. nasuta* suggest that it too is established. A rearing system has been

developed which enables coffee producers to produce their own *C. stephanoderis* for field release ("cría rural"). The experiences of coffee producers undertaking "cría rural" have been evaluated and a practical guide for use by producers has been published. A guide to estimating economic thresholds for CBB control is now being prepared. In a comparison of two lots within one coffee estate, CBB mortality within berries was below 5% in a lot without parasitoids, and 40-70% in a lot where parasitoids had been released. The eulophid parasitoid *Phymastichus coffea* was collected in Africa, quarantined in England, and reared in Mexico; however, the culture died out before field releases could be made. No introductions of the braconid *Heterospilus coffeicola* have been made, as it has not proved possible to rear in quarantine; quarantine rearing of any African species is essential to prevent possible introduction of coffee diseases into Mexico.

Of the four known parasitoids of the CBB, then, three have been introduced to Mexico, two have been field released, one is definitely established and apparently affecting CBB populations, and a second species is probably also established. This is a very reasonable proportion of success from any biocontrol project and reflects credit on the skills of the scientific staff involved. The main shortfall from the objectives is obviously the failure to maintain the colony of *P. coffea* until releases could be made. This would be a very desirable agent as it attacks a different stage of the CBB life cycle from the two bethylid parasitoids, and any mortality it causes would be directly additive to that caused by the bethylids. From the information available, however, it is hard to identify any technical reasons for the loss of this colony, as the same rearing methods were followed in Mexico as had been successfully used in quarantine rearing in England. Such setbacks are common when working with organisms whose biology has been little studied.

2.2 Current activities

Current or planned research activities in the coffee berry borer project include:

(a) Improvement of the diet rearing system for CBB (Ing. Gómez)

(b) Parasitoid rearing methods using CBB reared on diet (Ing. Infante)

(c) Isolation, evaluation and field testing of entomopathogenic fungi, especially *Beauveria bassiana* and *Metarhizium anisopliae*, against CBB. Some Mexican strains of *B. bassiana* have been identified which have high pathogenicity against the CBB, and studies are proceeding on methods of culturing, formulating and applying these as a mycoinsecticide (Ing. de la Rosa).

(d) Evaluation of the rural rearing system (Ing. Infante)

(e) Economic evaluation to compare the effects of massive parasitoid releases with smaller-scale releases from the "crías rurales" (studies being planned by Ms. Damon)

(f) A study to determine whether other plants can be used as supplementary food sources (pollen, nectar, etc.) by *C. stephanoderis* and whether such plants can be used to enhance parasitoid survival over the inter-harvest period when the host, CBB, is scarce. (studies being planned by Ms. Damon)

(g) Use of semiochemical baited traps for monitoring CBB populations (M.C. Gutierrez).

2.3 Needs

In my discussions I found the project team to be well aware of the directions of further investigation required, and I was not able to suggest any major new topics which had not been the subject at least of some preliminary work. However, I suggested that the following lines of research would be particularly important:

(a) Spatial dispersal of the parasitoid species.

Information on the rates of dispersal of *C. stephanoderis* and *P. nasuta* would be useful in planning release and management strategies for these parasitoids. As it is not practical to mark such small insects, such studies would need to be conducted by releasing the parasitoids into areas where they do not presently occur and sampling infested fruit at regular time intervals and increasing distances from the release points. With *C. stephanoderis* at least, such studies would need to be conducted soon, while areas free from the parasitoid are still available. The studies being planned by Ms. Damon will provide some information on this aspect for *C. stephanoderis*.

(b) Long-term sampling in selected sites.

Long-term sampling should be conducted at fixed sites over a period of several years, to establish population trends for CBB with and without the parasitoid species and to estimate levels of parasitism. Such sampling would be particularly useful if designed in such a way as to enable absolute populations and life table information to be calculated. It should therefore include estimates of the abundance of each life stage of the CBB and mortality factors as well as percentage of attacked berries and total standing crop of berries. The results will help to indicate whether the parasitoids will be effective as classical biocontrol agents, permanently reducing the CBB below economic levels without further intervention, or whether additional management techniques will be needed. Sampling sites should span a range of altitudes and environments, and include both arabica and robusta coffee.

(c) Interaction between *C. stephanoderis* and *P. nasuta*.

The two bethylid parasitoids introduced for biological control of CBB have similar biologies and attack the same stages of the CBB within the coffee berry. There is thus the potential for competitive interactions between them. The interactions between the two species are of theoretical interest as well as practical importance. A series of laboratory experiments in which fruit containing CBB is offered to both parasitoids could provide useful information on these interactions. Factors to be varied in these experiments could include:

- order of presentation of the two parasitoids
- developmental stage of CBB offered

- time interval between introducing the two parasitoid species
- numerical ratio of each species to CBB
- temperature

(d) Parasitoid survival strategies

The period between harvests, when coffee berries are absent and CBB is scarce, is obviously a critical factor affecting the survival of the parasitoids. No form of diapause in the immature stages is known for either parasitoid; they must therefore either survive the between-harvest period as free-living adults, or continue to breed on CBB in fallen berries. Another possibility might be the use of an alternate host during this period, although given the specialized biology of these parasitoids, this seems unlikely. Further information is required on how the parasitoids survive this period; this should assist in designing management systems to enhance their survival and effectiveness. The proposed studies on supplementary feeding by parasitoid adults will provide some of this information; possible sources of food to be considered should include aphid honeydew, coffee flowers and extrafloral as well as floral nectaries of other plants growing in the vicinity of the coffee. At present it is being recommended that some trees should be left unharvested, providing an "overwintering" resource of fallen infested berries to enhance the survival of the parasitoids. However, if parasitism rates are low, this practice will obviously also tend to enhance the survival of the CBB. Studies should therefore be undertaken to evaluate the relative rates of survival of the CBB and the parasitoids in fallen berries and the possibility of continued parasitoid breeding in fallen berries. These will help to indicate whether the practice of leaving trees unharvested tends, on balance, to reduce or increase CBB populations.

(e) Additional biocontrol agents

Further efforts would be worthwhile to introduce *Phymastichus coffea* and *Heterospilus coffeicola*. *P. coffea*, in particular, would be desirable as it attacks adults, a stage not parasitized by the two bethylids. However, the shortage of biological information on these two species appears to be the limiting factor at present preventing their use. Without such information it is not possible to understand the failure of *P. coffea* to survive in culture

in Mexico. Further biological information would also be needed to develop a rearing method for *H. coffeicola*, which has not yet been successfully mated in captivity. The necessary studies on these species would have to be carried out in their native range in Africa, and would include more detailed observations on their behaviour and life-history in the field, their environmental requirements, host-finding behaviour, the exact developmental stages of the host required, and the circumstances under which they are parasitized. These studies could be combined with surveys for further possible biocontrol agents in areas such as Ethiopia, which have not yet been surveyed (Murphy and Moore 1990). It would seem useful to explore wild populations of coffee as well as cultivated plantations in such surveys - it is not clear from the literature I have seen if this has been done.

3 Dissemination of research results

The results of the research project have been disseminated in two principal ways: through scientific publications and presentations at scientific meetings, and through extension and training activities aimed at the users of biocontrol technology.

3.1 Scientific publications

The project staff have been active and successful in publishing research results both in Mexican and international scientific journals. They frequently attend and give presentations at national and international scientific meetings. A list of publications and presentations was supplied. Since 1983 team members have been authors or co-authors of ten articles on CBB in refereed journals, with a further four in press. These articles have been accepted by journals published in Britain, France, Canada, Costa Rica and Mexico. They have also published eight extension articles or brochures, 20 full papers and 33 abstracts in proceedings of scientific meetings.

3.2 Extension and implementation

The main extension effort of the project has been directed toward the setting up of rearing units for *C. stephanoderis* operated by workers on the coffee plantations themselves. This system has allowed these coffee producers to become self-sufficient in parasitoid production. CIES staff have developed an effective and simple rearing system using materials readily available to the growers, have published a brochure explaining the procedure in non-technical terms, and have given numerous training sessions for various producer organizations.

I visited four of these "crías rurales": two on private "fincas" (estates owned by a single proprietor), one on an "ejido" (peasant community producing cooperatively on land granted to them by the federal government), and one in a private house in Tapachula. The owner of the latter has a finca at some 80 km from Tapachula and finds it more convenient to rear the parasitoids at her house and transport them out to the finca for field release.

These "crías" had been established for periods of time ranging from 3 years to 3 months. All the users seemed satisfied with the results obtained to date and I was impressed by the skill and dedication with which parasitoid production was being carried out, even by producers at a very low socio-economic and educational level. The oldest-established cría had achieved production rates of up to 1,800 parasitoids per day. Releases were terminated on this finca in May 1993 and the owner is now sampling infested coffee berries to determine rates of parasitism. The owner stated that CBB infestation rates have declined from 10% to less than 1% since biological control was implemented.

The rearing unit at the ejido "Nuevo Ixtepec" had been in operation since 1991 and had produced a total of 84,000 parasitoids since then. It is operated by 20 members as a cooperative rearing group, with one person in charge. It occupies a small shed built for the purpose, very neatly maintained with illustrated rearing instructions clearly posted on the walls and well-maintained production and attendance records. Each of the 20 collaborators works one day in turn and receives 50% of the parasitoids emerging on that day for release in his own coffee plot; the other 50% are used to maintain the culture.

3.2.1 Training courses

I attended the first day of a two-day training course provided by CIES staff (Ing. Infante, Ing. Gómez, Ms. Damon) for coffee workers of the "Union de Ejidos Prof. Otilio Montaño", who had expressed the desire to set up a "cría rural". CIES staff are by now experienced in giving these courses and have developed an effective package.

The course I attended was given at the Colegio Nacional de Educación Profesional (CONALEP) campus at Belisario Domínguez, Chiapas. This campus is part of a nationwide system for vocational/technical training. It provided excellent facilities, including a lecture theatre with video cassette player and a well-equipped laboratory with sufficient binocular microscopes to allow one for each group of about 8 participants in the course. Such facilities are not usually available for courses given in other locations; in these cases microscopes and other necessary equipment are transported to the site from CIES. The first day of the course included two videos on the risks of pesticides, introductions to the ideas of biological control, the life-cycle of the coffee berry borer and of the parasitoid *Cephalonomia stephanoderis*, a practical demonstration in the laboratory of the various life stages of the berry borer and the parasitoid, and an outline of the materials and procedures required for setting up a "cría rural".

The course was attended by approximately 35 workers from a group of ejidos. All were male, and of varying degrees of education. All claimed to be literate, although as I observed their note-taking during the course it became clear that, for some of the participants, writing was a laborious exercise. CIES staff seemed well able to explain the concepts involved, in language appropriate to the educational and cultural level of the course participants. The participants willingly engaged in questions and discussions, and I was impressed by their obvious desire to learn, their concentration and seriousness.

4 Research proposal

I reviewed the proposal which had originally been prepared by CIES staff in 1991 for a regional technology transfer program for biological control of the coffee berry borer. I felt that the general concept of the proposal was excellent. There is great interest among coffee producers in the region in obtaining training in the production of parasitoids for biocontrol of the coffee berry borer. The perceived benefits include a reduction in losses due to the borer, and a reduction in pesticide use. An increasing number of growers are also interested in the production of organic coffee, without the aid of chemical pesticides or fertilizers, which can be sold at a premium price. As world prices for coffee are currently depressed the economic advantages of this are clear.

CIES staff have been active in training users in the techniques of rearing and using *C. stephanoderis* and have already given numerous training courses. However, these courses are time-consuming, often requiring lengthy travel, and the number that can be given is limited. They inevitably cut into the time that CIES staff can devote to their primary function of research. The proposal would enable an expansion of the training program while allowing research activities to continue generating further information on biocontrol methods for the CBB.

In a detailed discussion of the proposal with Ing. Infante, I suggested a number of modifications which I felt would improve its efficacy and its prospects for receiving funding. The main points suggested were:

1. The proposal should be updated with information on recent research findings, and on the status of the pest and its parasitoids in 1993.

2. As presently written the proposal focusses solely on rearing and release of *C. stephanoderis*. It should make provision for implementation of further research findings with other potential biocontrol agents (e.g. *Prorops nasuta*, *Beauveria bassiana*), as the technology becomes available.

3. Since some of the objectives proposed have already been achieved (e.g. methods evaluation), the duration of the program could be reduced from three years to two.

4. The proposal envisages a series of training courses for field staff who will then become the agents for the actual delivery of training to users. These courses were planned to be two weeks in length. I suggested that they be reduced to one week to reduce costs and scheduling difficulties, and also because it may be difficult to maintain concentration and interest of the trainees for a full two-week course.

5. To date the "cría rural" training courses have been attended almost exclusively by men, although in evaluations it was subsequently found that women frequently become involved in the operation of the "cría rural", for instance by carrying out the daily maintenance while the men are away. A method should be found, if possible, to provide training directly to women, so as to enhance their skills and level of participation in the biocontrol program.

6. The proposal should clarify the role of the proposed "crías rurales" in the overall biocontrol strategy against the CBB. There are several possible ways in which a release program could function:

   (a) as a method of redistributing and establishing the parasitoids as classical biological control agents

   (b) as inoculative releases to boost rates of parasitism at critical seasons of the year, or

   (c) as massive releases in an inundative strategy to directly increase CBB mortality.

   Under the first of these options the rearing program could be terminated once the parasitoids were established throughout each coffee plantation, while either of the other two options would require a permanent rearing program. The third option may require numbers of parasitoids beyond the scope of a "cría rural" to produce.

7. More detail should be given of the content and function of the various extension materials to be developed (radio spots, flipcharts, video presentations).

8. The proposal should provide details of the responsibilities of each position which is proposed for funding, with a brief justification of the need for the position, and should also indicate the role and extent of involvement of any current CIES staff members who will be involved in the program.

9. It is proposed to set up 5 regional rearing centres to supply starter cultures of parasitoids to producers ready to initiate "crías rurales". The need for these centres and the rationale for their locations should be explained (to reduce travel time, provide better accessibility for producers in each region, etc.).

I discussed these suggestions at length with Ing. Infante, who was in agreement with all of them. He saw no difficulty in preparing a revised proposal for submission to IDRC incorporating these changes. We also discussed the geographic scope of the project. Although the CBB is now established in all coffee-growing areas of Mexico, including the states of Chiapas, Oaxaca, Puebla and Veracruz, we felt that the logistic difficulties and travel time involved would make it unrealistic to coordinate the project on a national scale. The proposal will therefore be limited to the state of Chiapas. If successful, it can serve as a model for similar programs in other coffee-growing states of Mexico.

5 Utilization of results in other coffee-grower regions

The technology developed at CIES for rural rearing of *C. stephanoderis* is simple and requires only materials which are readily available in most rural communities. During training courses and in their instructional materials, staff of CIES emphasize that a variety of different materials can be used; for example, emergence boxes can be specially built of wood or constructed from shoe boxes, cookie tins, etc. The exact dimensions and form of the rearing containers are not important. The rearing facilities do not require electric power,

although in cooler and higher elevation areas it is desirable to keep a light bulb lit over the culture containers to provide a little extra warmth.

The critical factors for the success of the "cría rural" are not the physical materials but the training of the operators and their care in carrying out the rearing procedures. In particular the selection of infested berries of the correct stage of ripeness (which will contain the correct life stages of CBB for parasitoid attack), the exclusion of ants from the rearing containers, and the daily removal of emerged parasitoids are important.

This is therefore a technology which could be readily adopted in any coffee-growing area infested with CBB. Through contacts of CIES staff with coffee researchers in other Central American countries, it is already being used very successfully in El Salvador and has been adopted in Guatemala and Honduras.

6 Recommendations

(a) IDRC should give favourable consideration to a proposal from CIES for a regional technology transfer program in biological control of the coffee berry borer incorporating the elements discussed in section 4, above.

(b) IDRC should promote the adoption of rural parasitoid rearing technology by other coffee-growing countries. A simple way to facilitate this would be by sponsoring the attendance of extension staff from other countries at the technical training sessions to be held as part of the regional technology transfer program.

(c) Further research at CIES should focus particularly on the ecology of the bethylid parasitoids (particularly dispersal and adaptations to survive the inter-harvest period) and field evaluation of their effects through long-term sampling at fixed sites.

(d) Further efforts to introduce the remaining parasitoid species from Africa, particularly

Phymastichus coffea, would be worthwhile. Such efforts will be more likely to be successful if preceded by field and laboratory studies in Africa to obtain more basic information on the biology of the parasitoid.

7 Bibliography

Murphy, S.T. and D. Moore. 1990. Biological control of the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera, Scolytidae): previous programmes and possibilities for the future. *Biocontrol News and Information* **11**:107-117.

Appendix 1

ITINERARY

Nov. 1, 1993	Travel	Edmonton-Dallas-Mexico City-Tapachula
Nov. 2		Public holiday in Mexico
Nov. 3		CIES - tour of facilities and laboratories, discussed research program with Ing. Infante
Nov. 4,	a.m.	Visited Moscamed and fruit fly facilities at Metapa, near Tapachula, with Dr. Liedo
	p.m.	Attended seminar by M.C. Antonio Gutierrez at CIES on use of baited traps to monitor CBB population fluctuations. Discussed status of biocontrol project with Dr. Liedo and Ing. Infante Received copy of technology transfer proposal
Nov. 5	a.m.	Reviewed technology transfer proposal
	p.m.	Discussed comments on proposal with Ing. Infante, began report preparation
Nov. 8	a.m.	Visited cría rural at finca of Lic. José Dardón
	p.m.	Visited cría rural at home of Sra. Sonnemann in Tapachula
Nov. 9		Visited crías rurales at Finca San Miguel and Ejido Nuevo Ixtepec
Nov. 10		Attended training course at Belisario Domínguez
Nov. 11	a.m.	Continued report preparation
	p.m.	Gave seminar for CIES staff on weed biocontrol programs in Alberta Lunch with Dr. Liedo, discussed CBB and other CIES projects
Nov. 12	a.m.	Final discussions on research needs and plans with Ing. Infante and Ms. Damon
	p.m.	Travel Tapachula-Mexico City
Nov. 13		Travel Mexico City-Dallas-Edmonton